CSE 333 – SECTION 5

C++ Classes, Const and References;

Some slides referenced from CSE 333 -Winter 2018 slides

Logistics

Friday (tomorrow)

Exercise 6 @ 10:00 am

Friday (1 week from now):

HW2 @ 11:00 pm

Mid-quarter Survey

Section Plan

- C++ const/reference refresher
- References Problem
- C++ Classes
- Mult-Choice Problem
- STL

Example

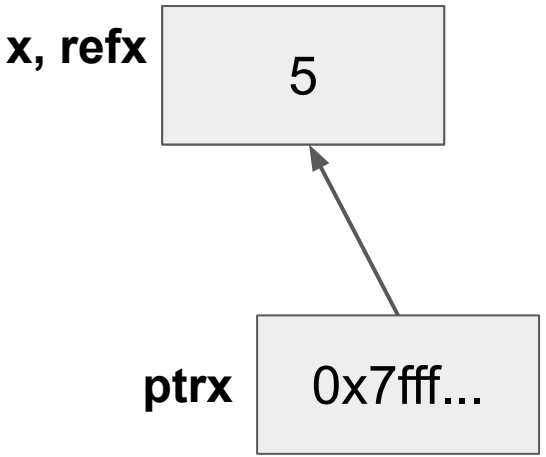
Similar in syntax to the * in pointer declarations

- Consider the following code:

```
int x = 5;
int &refx = x;
int *ptrx = &x;
```

Difference between declaring reference and 'address of' operator.

& in type declaration is for reference declaration. Elsewhere it is 'address of'



Legend

Red Thing = “can’t change the box it’s next to”
Black = “writeable/readable”

What are some tradeoffs to using pointers vs references?

Summary

- Pointers vs. References:

Pointers	References
Can move to different data via reassignment/pointer arithmetic	References the same data for its entire lifetime
Can be initialized to NULL	No sensible “default reference”
Used for output parameters e.g. `MyClass* output`	Used for input parameters e.g. `const MyClass& input`

When would you prefer reference to pointer as function parameters?

- When you don’t want to deal with pointer semantics, use references
- When you don’t want to copy stuff over (doesn’t create a copy, especially for parameters and/or return values), use references
- Style wise, we want to use **references for input parameters** and **pointers for output parameters**, with the output parameters declared last

Const

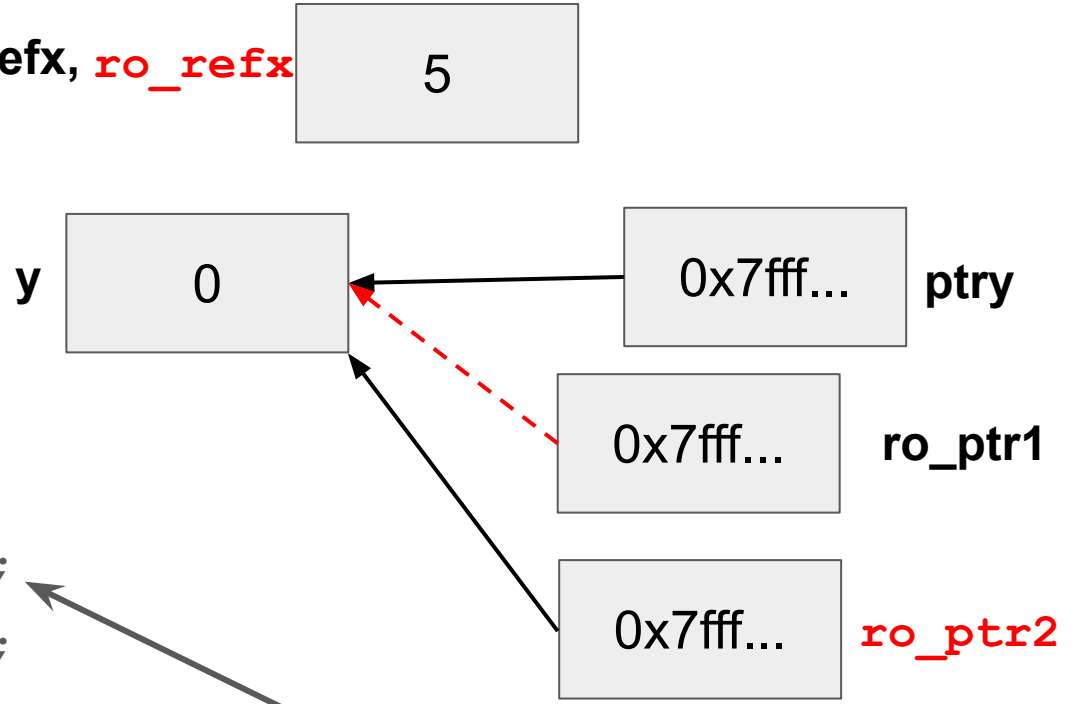
- Mark a variable with const to make a compile time check that a variable is never reassigned
- Does not change the underlying write-permissions for this variable

```
int x = 42;

const int* ro_ptr = &x;  // Read only

int* rw_ptr = &x;  // x can still be modified with rw_ptr!

int* const ptr = &x;  // Only ever points to x
```

Example (Ex 1)

- Consider the following code:

```
int x = 5, y = 0;
int &refx = x;
const int &ro_refx = x;
int *ptry = &y;
const int *ro_ptr1 = &y;
int *const ro_ptr2 = &y;
```



Tip: Read the declaration "right-to-left"

Legend

Red Thing = "can't change the box it's next to"
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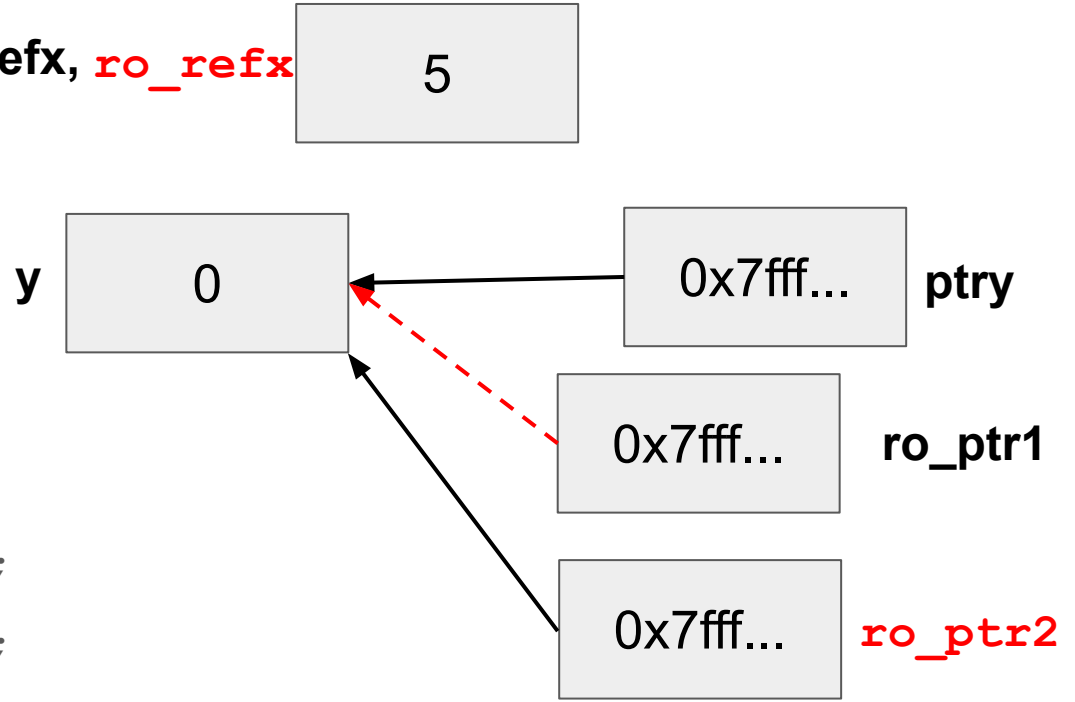
Example (Ex 1)

- Consider the following code:

```
int x = 5, y = 0;
int &refx = x;
const int &ro_refx = x;
int *ptry = &y;
const int *ro_ptr1 = &y;
int *const ro_ptr2 = &y;
```



Tip: Read the declaration "right-to-left"

Legend

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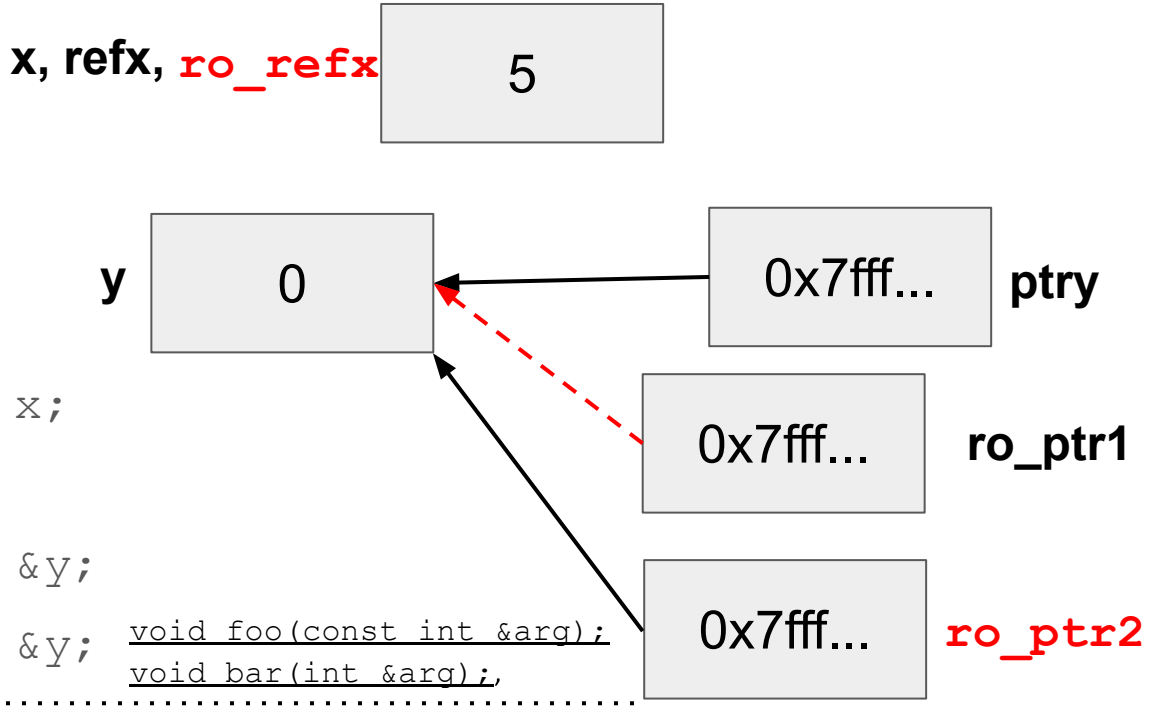
Example (Ex 1)

- Consider the following code:

```
int x = 5, y = 0;
int &refx = x;
const int &ro_refx = x;
int *ptry = &y;
const int *ro_ptr1 = &y;
int *const ro_ptr2 = &y;
```



Which results in a compiler error?

ok `bar(refx);`

Error `bar(ro_refx);`

ok `foo(refx);`

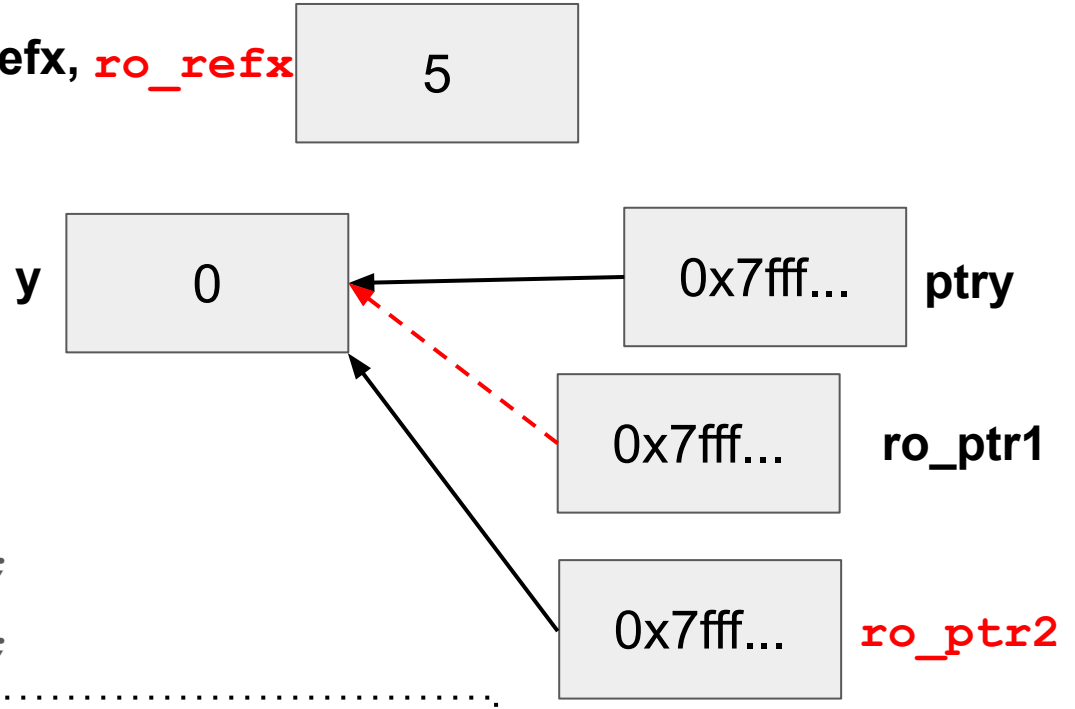
Legend

Red Thing = "can't change the box it's next to"
Black = "writeable/readable"

Example (Ex 1)

- Consider the following code:

```
int x = 5, y = 0;
int &refx = x;
const int &ro_refx = x;
int *ptry = &y;
const int *ro_ptr1 = &y;
int *const ro_ptr2 = &y;
```



Which of these results in a compiler error?

ok `ro_ptr1 = (int*)0xDEADBEEF;`

Error `ro_ptr2 = ro_ptr2 + 2;`

Error `*ro_ptr1 = *ro_ptr1 + 1;`

Legend

Red Thing = "can't change the box it's next to"
Black = "writeable/readable"

C++ Classes

Class Organization

Point.h

```
class Point {
 public:
  Point(int x, int y);
  int get_x() { return x_; }
  int get_y() { return y_; }
  double Distance(Point & p);
  void SetLocation(int x, int y);
 private:
  int x_;
  int y_;
};
```

Class declaration goes in Point.h, implementation goes in Point.cc.

Point.cc

```
Point::Point(int x, int y){
  x_ = x;
  this->y_ = y;
}

double Point::Distance(Point &p){
  double xdiff = pow(x_ - p.x_, 2);
  double ydiff = pow(y_ - p.y_, 2);
  return sqrt(xdiff + ydiff);
}

void Point::SetLocation(int x, int y){
  x_ = x;
  this->y_ = y;
}
```

Class .h files

Point.h

```
class Point {
 public:
  Point(int x, int y);
  int get_x() { return x_; }
  int get_y() { return y_; }
  double Distance(Point & p);
  void SetLocation(int x, int y);
 private:
  int x_;
  int y_;
};
```

- Includes the class declaration.
- Can specify member functions and variables and whether they are public/private
- Can have implementation of functions, usually only done with simple functions (e.g. getters)

Class .cc files

Contains member function definitions. These are indicated by: Class_Name::Func_name(){

If not specified as part of the class, it cannot access private class members, and probably won't compile.

Point.cc

```
Point::Point(int x, int y){
  x_ = x;
  this->y_ = y;
}

double Point::Distance(Point &p){
  double xdiff = pow(x_ - p.x_, 2);
  double ydiff = pow(y_ - p.y_, 2);
  return sqrt(xdiff + ydiff);
}

void Point::SetLocation(int x, int y){
  x_ = x;
  this->y_ = y;
}
```

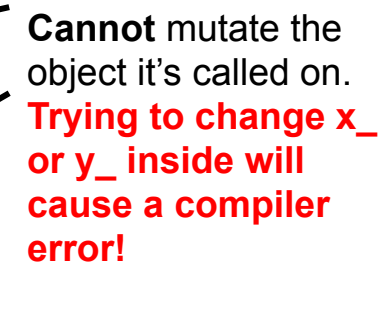
What about “const” object methods?

```
#ifndef POINT_H_
#define POINT_H_

class Point {
 public:
  Point(const int x, const int y);
  int get_x() const { return x_; }
  int get_y() const { return y_; }
  double Distance(const Point& p) const;
  void SetLocation(const int x, const int y);

 private:
  int x_;
  int y_;
};  // class Point

#endif
```



Cannot mutate the object it's called on. **Trying to change x_ or y_ inside will cause a compiler error!**

Exercise 3

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

 private:
  int  q_;     // question number
  char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

Code	Error?	Code	Error?

`int z = 5;`
`const int *x = &z;`
`int *y = &z;`
`x = y;`
`*x = *y;`
		`int z = 5;`
		`int *const w = &z;`
		`const int *const v =`
		`&z;`
		`*v = *w;`
		`*w = *v;`	

Exercise 3

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

 private:
  int  q_;     // question number
  char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

Code	Error?	Code	Error?

`int z = 5;`
`const int *x = &z;`
`int *y = &z;`
`x = y;`
`*x = *y;`
	N
	N
	N
	N
	Y
		`int z = 5;`
		`int *const w = &z;`
		`const int *const v =`
		`&z;`
		`*v = *w;`
		`*w = *v;`
			N
			N
			N
			Y
			N

Exercise 3

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

 private:
  int  q_;     // question number
  char resp_;  // response: 'A','B','C','D', or 'E'
};  // class MultChoice
```

Code	Error?	Code	Error?

`const MultChoice m1(1,'A');`
`MultChoice m2(2,'B');`
`cout << m1.get_resp();`
`cout << m2.get_q();`
		`const MultChoice m1(1,'A');`
		`MultChoice m2(2,'B');`
		`m1.Compare(m2);`
		`m2.Compare(m1);`	

Exercise 3

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

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```

Code	Error?	Code	Error?

`const MultChoice m1(1,'A');`
`MultChoice m2(2,'B');`
`cout << m1.get_resp();`
`cout << m2.get_q();`
	N
	N
	Y
	N
		`const MultChoice m1(1,'A');`
		`MultChoice m2(2,'B');`
		`m1.Compare(m2);`
		`m2.Compare(m1);`
			N
			N
			N
			Y

What would you change about the class declaration to make it better?

```
class MultChoice {
 public:
  MultChoice(int q, char resp) : q_(q), resp_(resp) { }  // 2-arg ctor
  int get_q() const { return q_; }
  char get_resp() { return resp_; }
  bool Compare(MultChoice &mc) const;  // do these MultChoice's match?

 private:
  int  q_;     // question number
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};  // class MultChoice
```

C++ STL

Templates

- C++ supports templates to facilitate generic data types
  - Parametric polymorphism - similar to Java generics but different in details (mainly implementation)
  - Example:
    - vector<int> x — vector of ints
    - vector<string> x — vector of strings
    - vector<vector<float>> x — vector of (vectors of floats)

STL (**S**tandard **T**emplate **L**ibrary)

- Set of C++ template classes that provide common programming functionality
  - A string class
  - Generic containers: queue, list, stack, vector, bitset, associative array, deque, and set
    - Iterators
    - Algorithms
  - And much more...

STL vector

- A generic, dynamically resizable array
- http://www.cplusplus.com/reference/stl/vector/vector/
- Elements are stored in contiguous memory locations
  - Elements can be accessed using pointer arithmetic if you'd like
  - Random access is O(1) time
- Adding/removing from the end is cheap (amortized constant time)
- Inserting/deleting from the middle or start is expensive (linear time)

STL iterator

- Each container has an iterator class
- http://www.cplusplus.com/reference/std/iterator/
- Ranges from **begin** to **end**
  - [begin, end)